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BIBLIOGRAPHY ON THE PLANNING ASPECTS OF AIR POLLUTION CONTROL. SUMMARY AND EVALUATION

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An examination of the literature covering planning principles in terms of their applicability to air pollution control. Subject matter is broken down into six major subheadings: elementary microclimatological considerations in city planning; relationship of air pollution to the "image" of the city; effects of "green areas" in air pollution control; relationship of transportation to air pollution; relationship of air pollution control to development patterns; regulation of pollution through performance standards and densities of population, industry, and traffic.

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Bibliography on the Planning Aspects of Air Pollution Control

Summary and Evaluation

Written by William J. Pelle, Jr. for
Northeastern Illinois Planning Commission
and
United States Public Health Service
December 18, 1964

NOTE: Research was limited to an examination of planning principles in terms of their applicability to air pollution control. Literature on related areas such as micrometeorology and the legal aspects of air pollution was examined only in so far as it was necessary to more completely understand the application of certain planning principles to air pollution control.

Subject matter in this field breaks down into six major subheadings: 1) Elementary microclimatological considerations in city planning; 2) Relationship of air pollution to the "image" of the city (includes aesthetic and psychological effects and the relation of air pollution to urban redevelopment); 3) Effects of "green areas" in air pollution control; 4) Relationship of transportation to air pollution; 5) Relationship of air pollution control to development patterns; 6) Regulation of pollution through performance standards and densities of population, industry, and traffic.

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I. Elementary Microclimatological Considerations in City Planning

In general, the most profound fluctuations in microclimate are due to variations in local topography, to the presence or absence of water bodies, to building mass, and to the structures and cover of the soil. Built up city areas cut wind velocity to about two-thirds of the values observed over free terrain; other effects of them include greatly decreased sunlight, lower humidity, temperatures higher on the average than those in open surroundings, lower wind velocities, and greater air pollution that drifts over other built up areas.[1] Alois Topitz in Der Aufbau states that any extensive construction

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has the effect of modifying winds of medium velocity, and that especially when the horizontal profile is irregular, all buildings act as barriers to air currents.[2] A uniform row of four story houses, for example, does less to interfere with air currents than does a row of low houses alternating with tall ones. Although wind velocities on the whole are decreased by urban areas, there are also funnel effects which occur on canyon like streets, where the velocity of the wind may easily be doubled. Landsberg has measurements which show that if wind hits a built-up street at an angle of about 45°, currents of quite high velocity will move down the windward side, while slower currents will move in the opposite direction along the leeward side. He further states that these currents will be further complicated locally by the presence of tall buildings, whose sunheated surfaces can set off convective currents of gale-like proportions.[3] This suggests that if enough were known about the factors involved, buildings could be so designed and grouped that these man-made winds could be largely controlled.

In his discussion of topography, Landsberg states that even a small change in elevation, such as might be found in the Chicago area, can cause large changes in free air temperature.[4] Other authors state that stability effects are more evident in hilly terrain where wind dispersal effects are correspondingly reduced.[5] Because valleys are more readily susceptible to inversions than level terrain, they are relatively poor locations for large industrial sites. In his discussion of orographic intersection of the plume with higher terrain, Munn states that, if there is any choice at all, one should not locate new industry in a valley, particularly if there are residential areas on the sides of the valley; but that if such a site is necessary, local building ordinances should be designed so that stack heights and exit velocities and temperatures insure effective stack height above the height of land.[6]

Valleys have more extreme temperatures than level terrain, and get warmer in daytime and colder at night. The manipulation of winds and air currents can be most effective with cities which lie in narrow valleys. Kuhn states that the natural channels of those cooling winds should be established,

and only then should construction be permitted in the areas between them; every building which interfers with this flow of air should be prohibited.[6a] He feels that blocks of houses situated at right angles to the slope permit these air currents to flow down into the city; houses built parallel to the slope should be raised on "piloti" so that the air can at least flow under them.[6b] Here, as everywhere else, areas of green serve to moderate the climatic conditions.

Comparison of possible industrial development sites can be made for an area by the use of a diffusion equation such as that used by Munn. If lapse rate data are available for one representative site in the city and if there are no disturbing orographic effects, then a method can be employed for making a crude operational decision for certain town planning problems. This is based on the frequency and strength of morning fumigations.[7]

When the factors mentioned above are related to the conventional determinants of land use, such as existing vacant land, cost of land, total demand for new industrial activity, and compatibility with adjacent land uses, optimum locations for industrial activity are better justified. In general, the ideal site for airborne wastes is comparatively level terrain in a region where the average wind velocity is of the order of ten miles per hour or more and where deep temperature inversions are a rare occurrence.

II. Relationship of Air Pollution to the "Image" of the city

Much literature on planning in relation to air pollution can be categorized by what Kevin Lynch calls "the image of the city". It deals with how people perceive of polluted areas. By the term "perception" is meant what people can see, what they can sense - not necessarily what is in the air, but what appears to people to be in the air. Complaint data, which can be ostensibly different from scientific data, reflects this view. Since the visible and unaesthetic effects of air pollution have a profound impact on people, planners can approach the air pollution problem on a psychological as well as a scientific basis. For example, an argument can be presented that absolute measures of pollution are meaningless since, for example, some people will perceive and complain of pollution solely on the degree of

blackness, and some persons who live in areas of heavy dustfall are not disturbed by the high count. If a green buffer, then, can conceal the sight of pollution, even if it has no scientific value for filtering out the pollution, it can be an effective psychological control measure.

On the basis of what they see, people will form certain images of cities and neighborhoods. Such images, divorced from economic considerations, have strong effects on both residential and industrial movement in and out of areas. Such psychological effects are recognized by both the medical and legal professions. Although U.S. courts have been reluctant to decide, without scientific evidence, how far it is reasonable to go to prevent a person or industry from expelling alien substances into the air, they have recognized the importance of psychological and psychosomatic effects: "...We recognize that smoke, disagreeable odors, industrial soot, and smog have adverse effects on the psychological as well as the physical well-being of populations."[8] Several recent court decisions, and in particular, the U. S. Supreme court decision in Berman v. Parker, 348 U. S. 26 (1954), show that aesthetics is being recognized as a proper municipal concern. Lynn Harriss, Executive Director of ASLA, states that "Pollution is detrimental in our 'pursuit of happiness', since there cannot be complete enjoyment of the outdoors."[9]

Articles in British periodicals on air pollutution state that in the eyes of southern England, there has always been an image of the north as being dark, dour and dirty. The Report of the Toothill Inquiry refers to the "depressing tenacity". Because of this image, it has become increasingly difficult to attract to the north the new industries, the capital, and a younger generation of technicians and trained executives.[10]

There have been studies in the United States which show the relationship between air pollution and blight and the need for concurrent and coordinated programs of air pollution control and urban redevelopment. Where blight occurs in addition to excessive visible pollution, a bad image is further intensified. In many studies, it is pointed out that the control of air pollution is vital to prevent the future deterioration and depreciation of residential areas.[11] In Pittsburgh, Detroit and Los Angeles, the worst

blighted housing areas paralleled fairly closely the location of the principal industrial districts which show the highest incidence of air pollution.[11a] In recognizing the relationship between land values and air pollution, George L. Schmutz in the Review of the Society of Residential Appraisers states that congruity is a condition essential to the value of residential properties, and that the absence of deed restrictions and zoning (which is often found in heavily polluted combined residential - industrial areas) exist because of the absence of protection from adverse influences such as unharmonious mixed land uses.[12] An excellent guide to the study of the hazards of location is the "Rating of Location" in the Underwriting Manual of FHA. It indicates conditions under which a property is not eligible for FHA insurance. Where there is an attempt made to relate pollution to building and land value in combined residential - industrial areas, there should be examined the extent of availability of FHA mortgages, since such money is an appreciable portion of the money market.

Attempts have been made in both the United States and Great Britain to coordinate redevelopment and the removal of slums with pollution control. Pittsburgh, in completely changing its image[12a] rebuilt areas of the city that possessed obsolescent heavy pollutant generating industries. The first "smokeless zone" in England (Manchester) was followed by three marginal extensions, together with five smaller zones in clearance areas which were scheduled to be redeveloped.[13]

The psychological affects of an "image" are related to the decrease in the amount of sunlight as well as the visibility of the smoke itself. A smoke pall over a city reduces solar radiation by as much as thirty per cent, invisible ultra-violet up to 50%.[14] Such decrease in the amount of light is viewed by architects and landscape architects as a handicap for full art and architectual appreciation and recreational enjoyment. Architects are placing an increasing emphasis on maximizing exposure to sun in the design of new buildings (ie: by orientation to the south and use of larger amounts of glass). Planners should begin to apply the same principle to groups of buildings especially where they are built in areas susceptible to long inversions or visibly "gray" areas. Lynn Harriss in his article entitled

"Air Pollution and the Greek Experience", looks at Greece as a country whose image is not tainted by the visible appearance of air pollution: "What matters above all...in the commanding beauty of Greece...is the quality of the light. Unlike other European cities, the light is brighter, cleaner, stronger...the beauty of the Greek landscape depends primarily on the light, and this had a powerful influence on the Greek vision of the world..."[15]

One planning technique which could be applied to change the image that air pollution provokes is a visual buffer device composed of planting. If a green strip area can conceal air pollution, a person's perception of air pollution could be changed. There would also be the additional advantage of the inherent value of the appearance of the green strip itself. Of course, the effect of obscuring nuisance is difficult to measure in quantitative terms, and its success in the realms of psychology and aesthetics rather than optics. However, comparison of the nature of complaints could be made before and after a visual buffer is built. Recommendations as to size of the green strip will be discussed in the next section.

III. Effects of "Green Areas" in Air Pollution Control

Few studies have been made in any country on the use of green areas as a control measure for air pollution. But where there is information on this subject, it is concluded that, on the whole, green "buffers" can be very effective as filtration devices, and, in fact, they are relatively more effective in the filtration of dust than they are in the reduction of noise. Measurements which were made in Leipzig a quarter century ago showed how wind confined within narrow streets was a bearer of dust, and how rapidly the dust was precipitated when the wind was spread out over a wide open area. So, if we want to apply planning remedies to purifying the air of dust, we could avoid having narrow corridor-like streets with their funnel action, and bear in mind

that every open space in the city reduces dust simply by diffusing the wind. Secondly, actual measurements indicate that a six hundred feet wide belt of planting can reduce dust count by about seventy-five per cent.[16] This was the case in the Leipzig study, where two hundred and ten dust particles per cubic centimeter were measured at a spot near where the wind issued from a narrow street, but at the end of an open space two hundred yards long the count was down to fifty.[17] Meetham discusses a less scientific study in his book, Atmospheric Pollution, where the distribution of smoke was measured in a London Park on ten afternoons in March, 1943. He found that the ratio of the smoke density at the center of the park to the density in the surroundings varied between about 1/4 and more than 5/6.[18] In short, the filtering effect of foliage and needles reduces dust and detoxicates the air of industrial waste gases by causing turbulence and deviation of the air-flow. In the third place, a green area contributes to the cleansing of air in so far as it produces no dust itself. An open lawn can do much, provided the wind is not too strong; and a green area planted with trees can help if it is so laid out that the wind does not leap over it, but becomes entangled in it.[19]

The complete studies that are mentioned above should be examined to see, for example, how much more effects the planting has on dust and smoke filtration than simply the distance that's involved. Also, it is implied in one of the above studies that stack heights on sources of dust emissions were no higher than the trees themselves, and that the green areas are located immediately adjacent to the emission source. These are obvious limitations to the application of the green area concept, but in certain industries where emission heights are relatively low, such as foundries, the problem is not as great.

As far as the role of green areas in the process of chemical conversion of carbon dioxide to oxygen, studies indicate inconsistencies in the value of green areas. On one hand it's pointed out that even very large areas of greenery are not capable of purifying the air by any chemical conversion. Camillo Sitte long ago pointed out that a wooded area of three acres can absorb only as much carbon dioxide as four human beings would produce in

the course of cooking, heating, breathing. Martin Wagner showed later that to improve the air of Berlin to any marked degree a green area of three million acres would be needed. It has also been estimated that the Tiergarten (which, before its destruction was half planted to trees) could assimilate no more than one and one-half per cent of the carbon dioxide produced every day in the central district of Berlin.[19] On the other hand, however, there are recent studies which indicate that "...air in a wooded area is a decisive factor in the oxygen-carbon dioxide cycle...and that a wooded area feeds a wide continuing stream of fresh air, with a high pressure of oxygen into adjacent industrialized areas."[20]

In a study of Hyde Park in London, the rate of decrease of concentration of atmospheric sulfur dioxide with distance from the upwind edge was found to be closely related to the lapse rate but not to the wind speed.[21] In this study, it was thought that because of the park and its relationship to adjacent built up areas, that cleaner air descended into the park by natural convection, with an upward current from the surrounding built up area.[22] Convection currents, then, appear to be a fourth way air pollution is alleviated in a green area. In the study it was also found that strong winds blow pollution into the park in a shallow layer. At low altitude, even a small extent of vertical mixing produces a significant reduction in ground level concentration; conversely, light winds bring in pollution at greater altitudes and a larger extent of vertical mixing is needed to reduce the ground level concentration.[23]

As already stated, alteration of wind currents is something that can be achieved with planting. From a planning point of view, it should be recognized that in addition to planted areas being used for "turbulence" and "break-up of movement" purposes, larger open surfaces in a city such as open parks and wide streets, because of lending themselves to greater movement of air masses, can help to disperse polluted air. This latter concept is more applicable in planning for a city as a unit, since, in dealing with a larger unit (in contrast to local effects, when planted areas adjacent to industry can act as filters), it may be desirable to funnel the

air out of the city before it is filtered. Alois Topitz in Der Aufbau states that since the warmer air of the city rises during the morning, cooler air is drawn from the rural environment; but if this environment is composed of open fields and large treeless areas baked in the sun, the circulating air will provide little refreshment to city dwellers. It is suggested, therefore, that the solution is to surround the built-up area with a park-like suburban landscape.[24] In practice, however, this solution is impractical because of economic considerations and our existing urban sprawl.

The literature has given some indication as to the type and placement of vegetation that would be needed for a green area designed to filter pollution. At this point, let it suffice to say that vegetation should be planted as close as practicable to sources of pollution. As to type of vegetation, it should be noted that conifers have been found to be more susceptible to toxic emissions than are deciduous trees, and secondly, that effective protection of soil against wind erosion is best achieved with deciduous plants, for conifers act more or less as a solid wall and only increase the action of the wind. Kuhn states that the best results come from a combination lawn and rows of trees and shrubbery.

It was brought out in the previous section that the concept of a "green buffer" could also be employed as a "visual buffer" in an effort to minimize the psychological impact of air pollution. The issue of the value of using a green buffer as a visual screen is less controversial than the issue of using if for filtration effects. In Planning Advisory Service Bulletin No. 133, "Zoning Buffers: Solution of Panacea?", quantitative measurements are given as to the width that is needed. In brief, a complete screen would need to be at least twenty feet wide and planted with an unusually dense growth.[25] As stated before, the effect of obsuring the nuisance is difficult to measure in quantitative terms, and its success is in the realms of psychology and aesthetics rather than optics. Kevin Lynch, however, does stress the importance of green areas having very positive effects on the formation of an image of an area.[26]

In existing zoning ordinances, the lateral width of buffer areas for

visual separation of land use ranges from eight feet to 150 feet. Except for specifying width, and sometimes height of shrubbery, few provisions attempt to set up standards that define a "buffer effect". The zoning ordinance of Sarasota, Florida is an exception, since it specifies a degree of opacity as well as height and maintenance of planting. Eighty per cent opacity must be secured within twelve months after the landscaping is begun.[27]

The buffer device has been an attempt to lessen incompatibility or to cancel out effects that would occur if a buffer were not there. It has been the policy to use a buffer when proximity of incompatible uses cannot be avoided, or when two objectives may conflict. It is recommended here for reasons already stated that increased use be made of the "visual buffer" to block out the sight of the pollution itself instead of, or in addition to, the whole structure itself that emits pollution. Experience shows that the plant material screening does not become effective until five or six years after planting. On the other hand, maintenance costs decline as the plantings mature. Tentative findings in Oak Park, Michigan, where the greenbelt idea has been employed, indicate that the adjoining residents for the most part are favorable to the green area idea and believe that green areas are desirable to live next to.[28] Where economic studies on greenbelts have been made, (ie: Oak Park, Michigan and West Orange, New Jersey[29]), there are indications that properties next to green areas have at least not decreased in value as a result of being located near a factory or road. Experience so far shows that maintenance is the big factor.

Countries other than the United States have considered green areas as control measures, which are used as both "visual"and "filtering" buffers, as, for example, in the Netherlands and in Belguim. At a recent International Clean Air Conference, it was pointed out that green areas in Belguim should vary, according to the district and density of population, from 35 to 60 per cent of the total area. The green area principle advocated by planning authorities in Great Britain separates industry and its emissions from the human perceptors; however, because of the British intuitive approach to much of their planning policy, no quantitative measurements seem to be

available in the relationship of the green area idea to air pollution control. In the USSR the suggestion has been made to remove the inhabitants from an area two kilometers in radius surrounding refineries and other specified industrial activities, thus creating a buffer zone.[31]

From references in the literature, there was found that several countries are either using the green area concept or they are proposing it as a solution to air pollution. Careful investigation of specific green area standards or recommended standards that exist in other countries should be made to fully understand the basis for much standards, but the mere fact that the green area concept is being considered as an air pollution control measure indicates certain positive feelings on the part of experts concerning the value of green areas.

IV. Relationship of Transportation to Air Pollution

On the whole, the air pollution problem from automobiles is worsening, although the problem in the Chicago area is probably not as severe as in other parts of the country; yet the problem as it relates to automobiles is one of the most difficult to control since the American public wants in no way to give up its freedom in the use of the automobile. Although new control devices for automobiles are perfected and are being made mandatory, there is continuing the increase in the number of cars and in the amount of automotive travel. Air pollution effects from transportation come not only from unburned hydrocarbons, but also from dirt that is agitated by the wheels of cars and trucks.[32]

In brief, it is important for planners to know that vehicular speed is an important factor in the control of automotive emissions. Emissions increase according to the extent of acceleration and deceleration. In a comparison of auto exhaust emissions of Cincinnati and Los Angeles, analysis of the emission data for individual vehicles indicated that average

vehicle speed is a measurable parameter that provides an adequate measure or index of emissions from a specific route. This parameter is related to traffic volume and peaks and route conditions, since the average vehicle speed reflects the engine power demands required by variations in topography of the route as well as the extent of acceleration, deceleration, cruise and idle driving.[33]

There will be no mention of existing planning principles that can be applied to transportation in regulating traffic, since this is beyond the scope of this paper. It should merely be stated that in addition to traffic volume and number and nature of trip lengths, the above factors should also be considered. For example, it was brought out in the air pollution literature that an extensive use of expressways in a metropolitan area would greatly reduce the contribution of motor cars to the over all urban pollution because of the minimization of acceleration, deceleration, and idling.[34] Likewise, grades on highways and roads increase the amount of acceleration and deceleration, thereby causing more pollution to occur.[35]

Literature on this subject of transportation states justification for reducing both pollution and traffic congestion through the use of electric trains. This is especially true in regard to British and Russian leterature.[36]

There have been proposals in England for "carless zones", whereby there would be certain areas where all motor vehicles are phohibited in an effort to minimize pollution from automobiles. There was a proposal by Robert Harling in the London Times (January 12, 1964) for converting Leicester Square, including three streets that lead from it, into an oasis free from traffic. Like the "smokeless zones" in England, the carless zones would at first be small, selected towns, town centers, around some cathedrals, in areas of historic or national importance.[37] Actually, this planning idea can and already is being applied in parts of the United States- ie: the conversion of shopping districts into malls; but on a larger scale (ie: Victor Gruen's plan for Fort Worth), this idea is obviously unfeasible.

V. Relationship of Air Pollution Control to Development Patterns

Air pollution control can have a marked effect on the pattern of development. There have been attempts to regulate land use on the basis of prevailing winds. For example, Stalingrad was laid out in two sections perpendicularly alined to the prevailing wind directions, resulting in a more favorable windward and a less favorable leeward side to the town. These two sections were further divided into multiple bands or zones, with the favorable section containing bands of parks, recreation areas and residences, and the leeward section containing industrial plants, railroads, and a greenbelted freeway area - the latter separating the industrial from the residential areas, and concealing them from one another. The wind typically passes first over recreational and park areas, then over residences, then over the greenbelted highway area, then over the industrial and railway area. The design also permits homes to be located only a few miles from the major pollution sources, which are also the work places for many of the townspeople.[38]

In the United States, in situations which are already sever in large cities, it will not help to locate new industries down wind. However, many smaller communities, which are still able to regulage location of new industry, can do this, although what may be downwind from one city may be upwind from another. Hilberseimer states that when prevailing winds are so distributed that the section of pollution dispersion does not exceed half a circle, a ribbon like settlement is possible. If it does exceed half a circle, only fan-shapped settlements can be formed, separated from each other by the extension of the polluted area.[39] Hilberseimer does not mention that such patterns should be based on the results of diffusion equations, which take into account meteorological factors in addition to prevailing winds.

The advantages of centralization and decentralization of industry is discussed in the literature. With an idea of thinning down mass emission loads, decentralization of industrial plant location may be advisable, or

where meteorological factors and the location of urban communities indicate, concentration of industrial plants to the leeward of all inhabited spots may be a solution. Depending on the dilution and dispersal, industrial sources of pollution may be located in zones where these conditions are favorable, or prohibited by zoning from selecting sites in narrow valleys whose walls shield the area and lower windspeeds. Hilberscimer, to protect the city of Chicago from air pollution, proposes that manufacturing industries which, by their very nature, pollute the air be located outside of the city, east and west of the Fox River and along the Illinois River. He suggests that the residential areas for these plants would be situated in a triangle free from air pollution because of the wind pattern.[40]

Some authors feel that land use control for air pollution should be made with decentralization of industry into theoretically equidistant satellite cites.[41] Taylor, Hasegawa and Chambers further state that indirect air pollution benefits might be derived from the possible reduction in automobile exhaust if industry were decentralized to the residential suburbs of the metropolitan area.[42] This concept, when discussed, usually implies "balanced" or "self-contained" satellite communities where people live, work and recreate in the same community. The concept of such planning on a metropolitan scale, in addition to spreading out the adverse pollution effects, would also reduce municipal costs, would rationalize the distribution of texes, and reduce the costs and time of commuting; but such a living pattern does not reflect the existing American way of life - the desire and need for constant mobility.

It is perhaps the <u>scale</u> of decentralization that should be criticized here. Any plan for decentralization on a metropolitan scale is more impractical than a plan for decentralization on a smaller scale. For example, concepts like that of Hilberseimer, involving setting aside every fifth block in green pattern cities, for green space, could lend themselves also to some decentralization of "clean" industries. Although, on this smaller scale, decentralization is still impractical, it at least is not impossible.

VI. Regulation of Pollution through Performance Standards and Zoning

Air pollution control offers an unique opportunity for conventional planning principles to be revamped. There should be regulation of land use activity rather than land use classification. For example, knowledge of such factors as wind directions and speeds (both to some extent a function of time), windflow patterns as affected by large land features, daily and seasonal amounts of air pollution and sunshine, permit the tracing of air sheds or meteorological - topographic districts on maps of land use, population densities, traffic flows, etc.

Air monitoring facilities in continous operation in strategic areas are now capable of yielding measurements which can be reduced to hourly maps showing air flow patterns over an area. Such maps may be laid over land use maps to give a basis for predicting in terms of dispersal and dilution characteristics of the area, urban concetrations, location of industries of various types, traffic flow, etc. - the levels of pollution likely to be reached at different times under air pollution control conditions. Secondly, there is a need for increased use of performance standards as a substitute for "use lists". Such performance standards should begin to reflect perceptive effects such as tolerance levels either in addition or or instead of scientific standards.

Some authors suggest that human activities can be coordinated with seasonal and diurnal variations in pollutant concentrations, which are affected by seasonal and diurnal variations in meteorology. The concentration of pollutants increases slowly in the hours before sunrise, falls to a slightly lower value during the day, and then decreases to a low value during the night. Also, the rate of dissipation of pollutants increases very rapidly to a high value within an hour after sunrise, and decreases to as low

value about one hour after sunset. During the period of the day when gustiness and lapse rate are increasing, the air is in a state of instability because of disturbances of mechanical and thermal origin. The capacity of this atmosphere for dilution and dispersion of contaminants[32] is then at its highest. Depending on the nature of the particular pollution problem, in connection with such fluctuations, intensity of land use and intensity of pedestrian and vehicular movement at different time periods in the day could be correspondingly regulated. For example, if automotive pollution was the major problem, traffic patterns could be regulated with daily variations, (ie: an effort to reduce peak loads could be made to reduce the absolute amount of pollution for a 24 hour period). Secondly, it has been found that the percentage of pollution coming from each of the different types of sources during the day (ie: industry, cars, incinerators) can change drastically. Frenkiel mentions that if concentration goes above a certain threshold at a certain time of the day, one might, for example, change the hours of operation of the incinerators to shift their pollution contribution to other hours.[43]

Another concept that is already being employed by Commonwealth Edison Company is the change of fuel from coal to another fuel upon meteorological advice that "downwash" conditions are likely to occur at a certain time. Other concepts include the possibility of collecting the pollutants during unfavorable meteorological conditions and dispersing them into the atmosphere at more favorable periods of the day.[44] Also, there is the concept of restricting industrial nuisances by having industrial districts that operate only one shift and may not operate Sundays, holidays or at night.[45] This concept would especially help to reduce the objection of integrating industrial with residential areas. Industry in terms of air pollution control is only incompatible to its adjacent land use when it emits an excessive amount of pollutants within a particular population density at a particular time. Recreational land use, for example, could be compatible with an adjacent industry if the industrial pollutants are emitted in excess concentration at a time the recreational land is not in use.

The use of various density controls have been proposed for population and industrial and automotive activity in an attempt to help control air pollution. On the whole, it seems that the greater the density of population and the multiplication of human activities, the more serious is the air pollution problem. Air samplings have shown that the highest concentrations of pollutants generally are encountered in the densely developed areas of the city and rapidly decreases as one moves toward the less densely populated surroundings.[46] In the literature, there are proposals to regulate population densities as part of an air pollution control effort. Increasing the use of land for public parks and green spaces is one technique that would reduce density as well as having the scientific effects that are described earlier in this paper.

Density controls have been suggested as a means of diluting the effects of noxious or toxic effluents of industry (ie: so much pollution per acre per hour) and in limiting the number of cars allowed in certain districts, or in limiting the number of employees per industry (in an effort to limit the amount of traffic). The only method now known to decrease traffic is to decrease the density of development. For the most part, regulation of traffic in terms of, for example, so many vehicle trips per acre per day, is unfeasible. Control of traffic generation by lot area and floor area ratio is far from satisfactory but it can bring a decrease in traffic generation, particularly where a floor area-to-site ratio of 0.50 or less is established.[48]

Implementation of the above mentioned concepts can be met through zoning. Although air pollution controls might at first seem to make the zoning ordinance more rigid, they can, in fact, offer greater flexibility to the ordinance as well as more quantification. Air pollution performance standards, which are used as a substitute for "use lists", permit industry to operate in compliance with certain technical limitations to locate in any zone for which it will meet standards, without regard to the type of operations conducted. With contamination limits rather than indefinite terms such as "detrimental, noxious, or offensive," industrial zoning becomes less arbitrary. Haar states that there is greater use of licensing

techniques, where there has risen over the years a number of special uses, admissible in specific districts, but only upon the discretionary grant of an application for a permit.[49] Industry, therefore, has a wider choice of locations. Because of performance standards, there is provided an incentive for improved pollution control in the design of new plants, because more desirable sites may be available if plants can meet the stack-emission and other requirements in the preferred zones.

Although the concept of performance standards is a relatively good one, there are some obvious weaknesses involved. For example, there is the difficulty of enforcement of a standard of so much pollution per acre per hour. Also, meteorological conditions are often not taken into account. For further insight into the advantages and disavantages of specific performances standards, the following are recommended:

1. Planning Advisory Service Information Report No. 78 "Industrial Zoning Standards", September, 1955 (American Society of Planning Officials)
2. Papers of the Annual Meeting of the Air Pollution Control Association in 1959:

   Industrial Zoning as a means of controlling Area Source Air Pollution.
   Holland, et al. Page 147 and following.
   April, 1960
   Performance Standards in Zoning, Schulze,
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   Why Industry Needs Performance Standard Zoning
   Muney, Page 282, August, 1960
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In an effort to prevent smoke in urban areas, Britain has employed the concept of "smokeless zones" The concept applies to all land uses whose activities generate smoke. In a smokeless zone, all smoke is scheduled to eventually be prohibited, and although the area of such a zone may to begin with be quite small, the intention is that it should be extended, until finally a whole town or district becomes smokeless. Changes are made in the kind of fuel and/or type of coal that is used. In

theory,"smokeless zones" take into account factors such as prevailing wind direction, existing pattern of residential and non-residential properties, existing and new population densities, Assuming that the prevailing wind direction is southwest and subject to no heavy industry in that direction, the southwesterly municipal boundary suggests itself as the datum line from which to establish successive zones downwind.[50]

Britain claims that the "smokeless zone" concept has generated enough enthusiam with people both inside and outside the zones that greater discrimination is being shown by householders in their choice of domestic fuels and heating appliances. Whereas in the earlier years following the Clean Air Act, the open fireplace burning a solid smokeless fuel became the popular alternative to the coal burning fire, there is now a definite trend in domestic heating towards fuels other than coal.[51]

One of the newest concepts that has been proposed in the United States is "air zoning" in which certain districts of a metropolitan area would be limited to an allowed maxima of pollutant concentrations.[52] This new concept, however, has been questionable because it involves air quality standards. For the most part it is difficult to determine a basis for the quantitative measurement, and, secondly, when a district goes beyond the limit, it is difficult to pinpoint the source or sources that should decrease its emission. Also, it seems arbitrary and somewhat undemocratic to regulate a source on this basis - since the final operation of that source depends on the relative operations of other sources in the district.

In conclusion, it should be noted that there is still much room for improvement and development performance standards, zoning and any other planning tools, that can be employed to implement an air pollution control program. Part of the difficulty is related to the fact that all of the effects of air pollution - health, economic, and psychological - have not been studied enough by professionals other than planners to better quantify certain existing standards, and to develop methodology for new approaches to air pollution control .

FOOTNOTES

1. Landsberg, H.E. "Microclimatology," Architectural Forum, March 1947, p. 119, and
Jackson, J.B. "Our Unexplored Surroundings," Landscape, Autumn, 1958, pp.26-28

2. Found in Landscape "Winds As A Factor in City Planning" Autumn, 1957, p. 16

3. Landsberg, H.E. "Microclimatology," Architectural Forum, March, 1947, p. 119

4. Ibid, p. 114
This is most marked on a clear calm night when a few feet of change in elevation can be equivalent to over a hundred miles change in latitude, i.e. a trough only 400 feet wide with a difference of 25 feet in elevation between bottom and crest. On a clear night with little wind, the lowest point shows a temperature 11 degrees colder than that of the crest, its relative humidity is 20% higher.

5. For example, see E.N. Lawrence, "Atmospheric Pollution (So 2) in Hilly Terrain," International Journal of Air and Water Pollution January-February, 1962, p. 5

6. R.E. Munn "Application of an Air Pollution Climatology to Town Planning" International Journal of Air and Water Pollution, April, 1959, Vol. 1, p. 278 (1959)

6a. Kuhn, Erich "Planning the City's Climate" Landscape Spring, 1959, p. 21

6b. Ibid, p. 23

7. Munn, R.E. (See footnote #6)

8. Ladimer, Irving "Medicolegal Aspects of Air Pollution Research" Archives of Environmental Health, pp. 772-778

9. Harriss, Lynn, "Air Pollution and the Greek Experience" Landscape Architecture April, 1963, p. 222

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10. "Image of the North" Smokeless Air , Spring, 1963, No. 125

11. (1) For example, See Witchita- Sedgewick County - Metropolitan Area Planning Department. "Pollution: Water - Air", February, 1961.

    (2) "Effect of Air Pollution on Real Estate Values." American City, March, 1940.

    (3) In the Donora incident, it was pointed out that some relationship appeared between severity of affection and certain characteristics of housing quality. (Public Health Bulletin No. 306 of Public Health Service, Federal Security Agency (1949)).

11a. Katz, Morris, "City Planning, Industrial Plant Location, and Air Pollution," Air Pollution Handbook, (1956).

12. Schmutz, George L. "The Hazards of Residential Locations" Review of Society of Residential Appraisers , May 1952, pp.3-8

13. J. Graham "Clean Air- The Relationship Between Land Use Planning and Air Pollution," Journal Town Planning Institute, June, 1957 p. 166

14. Landsberg, H.E. "Microclimatology," (See Footnote 1)

15. Harriss, Lynn, "Air Pollution and the Greek Experience" (See footnote 9)

16. Landsberg, H.E. "Microclimatology" p. 117 (See footnote 1) Also found in Landsberg, H.E. "The Climate of Towns," Man's Role in Changing the Face of the Earth, (edited by William L. Thomas) pp. 588-589 (1956)

17. (1) Geiger, Rudolph, The Climate Near the Ground, pp. 380-383
    (2) Kuhn, Erich (See Footnote 6a)

18. Meetham, A.R. Atmospheric Pollution (1956), p. 194-195. It should be noted, however, that Meetham states that the area of the park (about 1 square mile) is really too small to be an effective "smokeless zone."

FOOTNOTES

19a. Kuhn, Erich, p. 21 (See footnote 6a)

19b. Ibid, p. 21

20. Abstract of "Woods as a Natural Barrier Against Air Pollution in Areas of Concentrated Industrialization and Urbanization." (In German).
Weisser, D. (Wasser Luft u Betrieb, March, 1961, Weisbaden, 5,96-8)

21. Wainwright, G.W.K. and Wilson, M.J.G. "Atmospheric Pollution in a London Park" International Journal of Air and Water Pollution 1962, Vol.6, p. 346

22. Ibid, p. 346

23. Furthermore, Braun and Wilson (1961) found with a balloon-borne apparatus on a day of light wind (7 knots or less) the concentration was much the same at heights of 100 and 500 feet above ground. On that occasion the amount of sulfur dioxideblown past the sampling point at heights up to 500 feet accounted for only about 1/3 of the total estimated substantive even at heights of 1 or 2 thousand feet. Similar results were found on other occasions and unless some convective circulation is postulated, it seems difficult to realize these deep layers of pollution with the rapid removal found in Hyde Park.

24. "Winds As a Factor in City Planning" (See footnote 2)

25. American Society of Planning Officials, PAS Report No, 133 "Zoning Buffers: Solution or Panacea?" April 1960, p. 11

26. See Lynch, Kevin and Rivkin, Malcolm. "A Walk Around the Block" Landscape, Spring, 1957, pp.24-34

27. For other examples, see American Society of Planning Officials, PAS Report No. 133, pp. 16-30

28. Ibid, p. 12

29. Ibid, p. 12. Also, Hendricks, Robt. W. "Residential Amenities Along Freeways," Review of Society of Residential Appraisers

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30. Ebenezer, Howard (1946)

31. Goldberg, M.S. (1948), The Sanitary Protection of Air, Moscow, p. 119.

32. American Society of Planning Officials, PAS Report No. 32 "Performance Standards in Industrial Zoning."

33. See "Comparison of Auto Exhaust Emmissions From Two Major Cities," A.H. Rose, R. Smith, W.F. McMichael, R.E. Kruse U.S. Public Health Service

34. F.N. Frenkiel, "Atmospheric Pollution and Zoning in an Urban Area" Detroit Conference, May 22-26, 1955, p. 11

35. Robt. W. Hendricks "Residential Amenities Along Freeways" Review of the Society of Residential Appraisers

36. For example, see "Road Pollution and Traffic Congestion - A Way to Reduce Both," Smokeless Air, Spring, 1962, pp. 208-211

37. Arnold Marsh, "Why Not Carless Zones?" Smokeless Air, Autumn, 1963, No. 127

38. Proceedings of the National Conference on Air Pollution, December 10-12, 1962, Public Health Service, p. 197

39. Hilberseimer, L. Nature of Cities, p. 199-201

40. Ibid, p. 253

41. For example, see p. 196 Proceedings of the National Conference on Air Pollution, December 10-12, 1962, Public Health Service, p. 197

42. World Health Organization, Air Pollution, (1961), p. 303

43. Frenkiel, F.N. "Atmospheric Pollution and Zoning in an Urban Area" (See footnote 34) It was found that the relative amounts of pollutants emotted during 24 hour basis were:
industry 29%, Cars 55%, incinerators 16%
Contributions of above three sources at 8 A.M.:
industry 13 %, cars 51%, incinerators 36%

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